Computer Aided Discovery and Algorithmic Synthesis for Spatio-Temporal Phenomena in InSAR

Completed Technology Project (2017 - 2019)

Project Introduction

Objectives and Benefits: The goal of this research is to provide Earth scientists with a computer-aided discovery environment that advances the synthesis of computational pipelines and which creates new artificial intelligence (AI) guided capabilities for the discovery of deformation phenomena in Interferometric Synthetic Aperture Radar (InSAR) data. The project will provide new cloud-scalable algorithms, tools, and data fusion capabilities for different instruments to enable complex spatio-temporal inferences on big data sets. Work & Methodology: Interferometric Synthetic Aperture Radar (InSAR) has become a key technique in analyzing effects such as subsidence, co-seismic offsets after earthquakes, effects of volcano inflation and eruptions, and other natural phenomena related to global hazards and threats to human life. InSAR enables detections of deformations based on imaging with millimeter sensitivity over swath widths of up to 400 km. However, InSAR data processing is currently facing numerous challenges. Data sets are drastically increasing in size for current operations, and new missions like NASA ISRO SAR (NISAR) will increase the temporal density of InSAR images by orders of magnitude. While current NASA systems like ARIA are focusing on storage, retrieval, and generation of interferograms with Web-based techniques, new discovery and prediction capabilities are needed as a layer on top. Computational workflows generating interferograms and higher-level data products are highly complex (e.g., due to corrections for atmosphere, ionosphere, instrumental biases etc.). These workflows require a sophisticated search and adaptation of algorithmic choices and parameters to generate data products that visually amplify interesting phenomena that would lead to new discoveries. Yet another challenge includes data fusion with thousands of GPS sites worldwide, as well as instruments such as MODIS and GRACE, for purposes of eliminating false positives and maximizing phenomena information in temporal and spatial dimensions. Addressing these challenges, this research will leverage the current NASA InSAR and NASA UAVSAR data efforts, and expand the successful NASA AIST14 Computer-Aided Discovery project with InSAR capabilities. Our cloud environment will allow scientists to programmatically express hypothesized scenarios, constraints, and model variants (e.g. parameters, choice of algorithms, workflow alternatives), to automatically explore with machine learning the combinatorial search space of possible model applications in parallel on multiple data sets. This project will also investigate new AI-based methods for generating and pruning geophysical models aimed at phenomena characterization, as well as processing pipeline synthesis for InSAR workflows. All capabilities will be demonstrated in the context of concrete case studies. (1) Algorithmic coherence improvement in areas of de-correlation through enhanced phase matching between interferograms. (2) Model exploration and extraction of Episodic Tremor and Slip events in InSAR with improved coherence, applied to the Pacific Northwest and Guerrero, Southern Mexico regions. (3) Exploration of novel algorithmic approaches to directly generate InSAR time series without forming interferograms and using filtering and state estimation rather than

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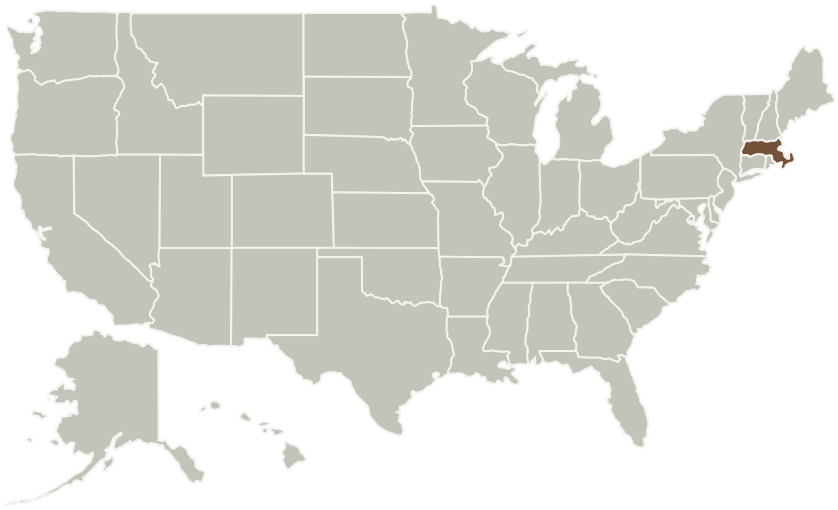
differencing. Significance: Our proposal will advance NASA's capability for modeling, assessment, and computing of Earth Science data (3.1.2 Computational Technologies) and improve technical means to assess, mitigate, and forecast natural hazards. Computer-aided discovery will enhance the productivity and ability of scientists to process big data from a variety of sources and generate new insight. Period of Performance: 8/1/2017 - 7/31/2019 Entry/Exit TRL: 3 / 5

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Massachusetts Institute of Technology(MIT)	Lead Organization	Academia	Cambridge, Massachusetts

Primary U.S. Work Locations
Massachusetts

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Massachusetts Institute of Technology (MIT)

Responsible Program:

Advanced Information Systems Technology

Project Management

Program Director:

Pamela S Millar

Program Manager:

Jacqueline J Le Moigne

Principal Investigator:

Victor Pankratius

Co-Investigators:

Thomas A Herring
Veronica Anne Morris

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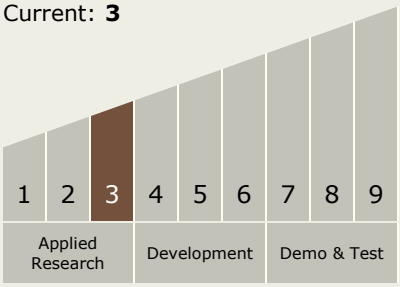
Technology Maturity (TRL)

Start: **3**
Current: **3**



Technology Areas

Primary:

- TX11 Software, Modeling, Simulation, and Information Processing
  - TX11.4 Information Processing
    - TX11.4.1 Science, Engineering, and Mission Data Lifecycle

Target Destination

Earth